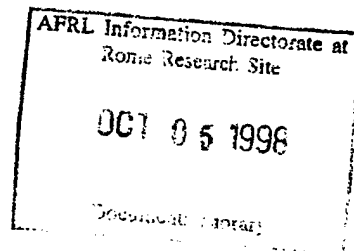


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Final Technical Report
August 1998



GCCS SPATIAL DATA BASE MODULE

Sterling Software

Paul Bell, David Kolassa, Michael McQuinn, Sandra Stoltz, David Kane, Michael Seakan and Robert Marceau

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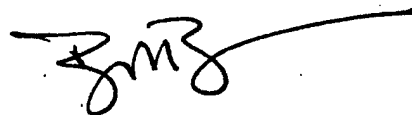
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PREFACE

This document presents the Final Technical Report of the Global Command and Control System (GCCS) Spatial Data Base Module (SDBM) effort sponsored by Rome Laboratory. The SDBM project focused on the design of a geospatial data base to support the Mapping, Charting, Geodesy, and Imagery (MCG&I) requirements of the GCCS. A baseline implementation resulting from the design was developed and demonstrated as a module of the Joint Mapping Toolkit (JMTK).

The report is organized into five sections with three appendices. The introductory section identifies the program and provides a background of the effort and the unique objectives that were outlined at the start of the effort. An overview of the specific accomplishments made during the effort is also provided in the introduction. Section 2 provides the details of the technical approach used to achieve the objectives of the effort. A complete description of the Spatial Data Base Module is presented in Section 3 that includes both the data base architecture and the software components to utilize it. In Section 4, we describe additional work performed under the effort to support the development of the GCCS/JMTK. A utility that was implemented and used to identify functionality needed in the next version of the JMTK is described along with an approach for migrating from the Air Force's Common Mapping Toolkit (CMTK) to the future JMTK. Section 5 ends the report with the results obtained from the prototype developments and the conclusions and recommendations.

Major Robert Gibson was the Rome Laboratory/IRRP Project Engineer. Mr. Paul Bell was the Sterling Software Project Manager who directed a project staff that included Mr. David Kolassa, Mr. Michael McQuinn, Ms. Sandra Stoltz, Mr. David Kane, Mr. Michael Seakan, and Mr. Robert Marceau. The Sterling Software SDBM project team is grateful to the leadership and technical support provided by Major Robert Gibson and RL/IRRP during the course of the effort. We are also grateful to Mr. James Kwolek, Defense Mapping Agency (DMA) for valuable data production and operational insights that helped make this project successful.

SECTION 1 INTRODUCTION

1.1 Identification

This Final Technical Report describes the activities performed by Sterling Software, Information Technology Division (ITD) under the Rome Laboratory (RL) sponsored program entitled the Global Command and Control System (GCCS)/Joint Mapping Toolkit (JMTK) Spatial Data Base Module (SDBM). The project was conducted for the RL Image Products Branch (IRRP) with the end customer being the DMA. This nine month effort developed an initial Spatial Data Base Module for the Joint Mapping Toolkit. The SDBM will be used within the JMTK to import and maintain native DMA products.

1.2 Program Background and Objectives

The GCCS is the primary joint command, control, communications, computer and intelligence systems for the United States Department of Defense (DoD). GCCS variants (system and workstation configurations of GCCS compliant software) utilize applications developed by many formal acquisition programs (e.g., Standard Theater Army Command and Control System, Contingency Theater Air Control System Automated Planning System, and the Operations Support System) to provide an integrated capability at most levels of command. Development of GCCS is managed by the Defense Information Systems Agency (DISA). The GCCS method, architecture, environment, and core software are also used by components of the DoD (e.g., U.S. Navy, U.S. Marine Corps, U.S. Air Force, U.S. Army, DoD Intelligence, Defense Mapping Agency, etc.) for command and control related projects.

Due to the integration philosophy and techniques adapted by GCCS projects, DISA and partner organizations are able to now field more capable systems cost effectively. By standardizing the way the software is built and integrated, duplication of effort is avoided through software reuse. Standardization goes beyond the structure of the software. Use of common software to achieve certain key command and control capabilities, not only provides a common interface for client software, but ensures that the user sees predictable behavior and a familiar user interface for capabilities that are found at a variety of command centers. Training requirements are thus reduced and user proficiency is increased. Interoperability also results from ensuring that critical command, control, and intelligence data is processed by the same software regardless of what GCCS variant is being used.

GCCS is not a DoD development program. There is no prime contractor for GCCS. Rather GCCS is a strategy, technique, and set of standards for leveraging the development efforts of a large number of programs, each of which may have one or several development companies and organizations. All participating programs benefit from the work done by other organizations.

As a response to shifting budgetary priorities that have resulted in funding reductions for research and development of new command and control systems, the Department of Defense began using two development methods that significantly differed from previous practice. The first was evolutionary acquisition or development (EA or ED). A system developed under ED does not go through a laborious specification process before development. Instead the system is built up and fielded in a series of increments.

The second concept is that rather than building a large system broken down into modules through structured analysis (which would require the up front investment in the specification process), software is integrated "up" from:

- a Common Operating Environment (COE)
- existing Commercial-Off-The-Shelf (COTS) products
- Government-Off-The-Shelf (GOTS) software
- newly developed software to satisfy the needs of the user community

This approach to integrating software requires that the software operate in an environment flexible and robust enough to satisfy the resource requirements of such a diverse set of computer programs. It also requires that software products be built and selected to conform to a rigorous set of standards ensuring that all application will come together as one entity.

DISA recently decided to consolidate command and control systems under development into a single architecture, making use of a core set of software services. These projects develop application software that will follow strict standards and use common core products for all applicable functions. By taking this approach, software developed by one organization can be incorporated at any type of command center simply by choosing to include it in the installed system. This approach will make optimal use of program resources and increase the capabilities available to the user communities.

The Global Command and Control System (GCCS) has a binary dynamic library, known as the Common Operating Environment (COE), as a universal application foundation. The COE is divided into nineteen functional areas, one of which is mapping. This portion is referred to as the Joint Mapping Toolkit (JMTK). The Joint Services Working Group (JSWG)/COE for mapping has been formed to guide and facilitate the service members contributing to the JMTK. The JSWG/COE members have divided the mapping portion of the COE into three primary areas. These areas are 1) Visual, 2) Non-visual (analysis), and 3) Spatial Data Base. Given the ambitious schedule of the GCCS, the JSWG/COE has elected to tap each services' assets to provide functionality to JMTK; Navy's Chart II software to fulfill the Visual; Army's Topographic Evaluation Module (TEM) for the Non-visual; and the Air Force Common Mapping Toolkit (CMTK) for the Spatial Data Base portion. Software modules from all services may well migrate and integrate into all areas of the Mapping COE toolkit in due time. These selections are only an initial departure point to construct a Mapping COE toolkit which will allow "first-start" functionality for GCCS.

The primary objective of this SDBM effort is to define, design, develop, and test mapping, charting and geodesy (MC&G) spatial data base management and data access software for inclusion as the Spatial Data Base Module of the GCCS COE Joint Mapping Toolkit. The Spatial Data Base Module utilized the current CMTK MC&G software as the basis for the initial functionality of GCCS.

The baseline Spatial Data Base as a component of the GCCS/COE JMTK contains the following capabilities: import DMA data in standard formats (VPF, RPF, DTED); archive DMA data in the original format without reformatting any data (preprocessing); and provide data access and retrieval through the use of public Application Programmer Interface (API) functions. The information contained in this final report represents a summary of the SDBM program background, objectives, technical approach, and functional capabilities of the SDBM Import application, public APIs, thread tracking capability, and SDBM/CMTK integration prototype performed and developed under this effort.

1.3 Summary of Accomplishments

Five major accomplishments were achieved during the SDBM contract. The first of these accomplishments was the development of an SDBM Import application. The SDBM Import application is a graphical application used to assist in the creation of spatial data bases, the importation of standard DMA data, and the building of metadata. The second significant accomplishment was the development of the public as well as private API functions. Eleven public API functions were developed and used within the SDBM Import application as well as thirty-three private API functions in support of the public API functions. The API functions were developed and documented according to JMTK Working Group standards. A Thread Tracking utility was developed during this effort to provide developers, users, and integrators of JMTK with the capability to track the functional hierarchy (function threads) of functions within a toolkit such as SDBM in order to support the analysis and documentation of the functional flow within the API.

A CMTK-to-JMTK migration plan was developed during the SDBM effort. This plan provides an approach for current CMTK users to gradually transfer from the CMTK to the JMTK without introducing redevelopment costs or causing a delay in program development due to the migration of CMTK to JMTK. This plan received enthusiastic support during every briefing.

The final notable accomplishment of this effort was the development of a prototype demonstration which presented the feasibility of the initial step of the CMTK-to-JMTK migration plan, the integration of the SDBM into CMTK. The purpose of this demonstration was to show that an end user application would not require modification, standard DMA data could be used, preprocessing data could be eliminated, and access to the data in the standard format are all possible.

During this contract the following deliverables and technical documentation were delivered: Monthly Status Reports, Spatial Data Base and Data Access Requirements Document, SDBM User's Manual, SDBM Implementation Plan, Software Test Description, Software Test Plan, Presentation Materials, Configuration Management Plan, SDBM Computer Software (C with Ada Bindings), Error Handling Approach within SDBM, Thread Tracking Capability, SDT Thread Analysis, and the Software Engineering Practices.

SECTION 2 PROGRAM OVERVIEW

2.1 Functional Analysis

In the area of MCG&I, each of the Joint forces' individual services has maintained its own software products which perform MCG&I functionality. Although that functionality is quite similar among software products, the implementation of the functionality is not. It is to this end that the GCCS is attempting to incorporate a COE to provide just that functionality. The GCCS has been attempting to obtain the best portions of each of these software products and integrate them into a JMTK environment.

Sterling Software took the initiative to perform a functional analysis on a group of these software products to analyze re-use opportunities prior to the design and development of the GCCS SDBM. Under this effort, Sterling Software compiled a significant amount of functional data from a wide variety of sources. The information was compiled from the JMTK Software Requirements Specification (SRS) Document, the currently existing requirements produced by the JMTK Working Group and specified within the GCCS SDBM Statement of Work (SOW), and requirements from such systems as the Air Force Mission Support System (AFMSS) and Theater Battle Management Core System (TBMCS). After gathering this information under one cover, Sterling produced its own SRS based upon the gathered information. The results from this functional analysis drove the design of the GCCS SDBM for the Joint Mapping Community.

2.2 Module Design

The objective of this phase was to define and design MC&G spatial data base management and data access software for inclusion as the Spatial Data Base Module of the Global Command and Control System Core Operating Environment Joint Mapping Toolkit. The SDBM was designed to be one of three architecture components of the JMTK, with the other two components consisting of the Visualization Module (displays of maps and overlays), and the Analysis Module (terrain analysis, line of sight, etc.).

Sterling Software defined the spatial data base and data access requirements for the GCCS SDBM effort through two means:

1. By providing assistance and becoming actively involved with the JMTK Working Group, to define the Application Programming Interface for the Spatial Data Base and Data Access software.
2. By analyzing existing DMA MCG&I datasets (e.g., CADRG, VMAP Level 0, DTED, etc.) to define data commonalty among the various mapping products and provided proposed solutions to limit and/or eliminate redundant data.

Under the Module Design of this effort, Sterling Software designed a GCCS SDBM which was compliant with the GCCS COE Data Management, Data Access, and Data Interchange Services. This module provided full support for the access and data base management of MCG&I data required by the GCCS JMTK Visualization and Nonvisualization modules. This task was achieved by examining and thoroughly understanding the current COE components. Sterling Software designed data base management functions for the GCCS SDBM which incorporated the following functionality:

- store graphical data such as Vector Product Format (VPF) data, Raster Product Format (RPF), and Digital Terrain Elevation Data (DTED)
- store analysis data for functions such as mobility and terrain analysis
- query and retrieve data base files, against both on-line and off-line product data bases, by geographic coordinate and product type
- provide access to the graphical and analysis data for functions such as mobility and terrain analysis
- obtain metadata on imported graphical data such as file size, file content, data base accuracies, feature/attribute information, and other metadata in accordance with Federal Geographic Data Committee (FGDC) Metadata Content Standard

The data base management functions designed under this phase for the GCCS SDBM maintained a consistency with the specifications identified within the Functional Specification for the Joint Mapping Toolkit as those specifications pertain to the task of data base management for the JMTK and, therefore, the GCCS SDBM. Sterling Software also designed a COE-compliant DIS to import and export MCG&I datasets and associated metadata to and from the GCCS SDBM. The DIS design allowed for the import and export of MCG&I datasets in their native DMA formats. The DIS design also allowed the datasets to be accessible from the associated storage media of each data type.

2.3 Development and Integration

Sterling Software has developed an initial baseline of the Spatial Data Base Module. The initial implementation includes the support of CADRG, DCW, and DTED datasets, and associated metadata. The initial implementation performs the Data Base Management functions, the Data Access Functions, and the Data Interchange Service functions described in Section 2.2 and relevant to the support of the datasets.

All computer software designed and developed for this effort adheres to MIL-STD-498, entitled *Software Development and Documentation*, dated 5 December 1994. Also, all SDBM software APIs have been developed in C and with supporting ADA bindings. All software delivered under this task is completely maintainable and modifiable with no reliance on any non-delivered computer programs and documentation. All software has been developed and tested under the following platforms and operating systems:

- Sun Workstation - Solaris 2.4, SunOS 4.1.3
- Hewlett Packard - HP-UX 10.0.1

All JMTK software components are compatible with the following commercial and public software versions:

- X11 R5
- OSF Motif 1.2.2

The GCCS SDBM software has undergone multiple integration steps through its life cycle. Sterling Software supported all integration activities in accordance with the GCCS Integration Standard. The following identifies the main areas of integration that Sterling Software has supported:

- integration of the MCG&I data server into the GCCS COE
- integration of all SDBM APIs and functional software into the GCCS JMTK

Sterling Software provided continuous support in the above areas throughout the SDBM task. In assisting in the integration effort of the GCCS SDBM, Sterling Software utilized the Telnet communication capabilities that were established during this SDBM effort, and that has proven to be a highly efficient method of integration, trouble shooting, and maintenance support for this effort.

2.4 Testing

The GCCS SDBM software has undergone rigorous testing throughout the development cycle of this effort. Modularized software has been tested thoroughly by each individual engineer responsible for a particular unit/portion of software that was developed before it was integrated into the baseline of SDBM. The baseline SDBM was also thoroughly tested on a regular basis to ensure that incorporation of software modules function were well within the bounds of the SDBM.

Sterling Software performed extensive test procedures, at the Sterling Rome, NY office, of all capabilities of the GCCS SDBM enhancements in order to verify that all requirements for the GCCS SDBM effort were met upon the conclusion of this effort. A Software Test Description document has been written to direct and present the format of the test plan, test descriptions, and test procedures for the GCCS SDBM effort. Equivalent test procedures were performed following the Software Test Description document at the designated Government facility upon installation of the GCCS SDBM enhancements. A Software Test Plan was also written and provided to the Government in order to specify the exact times, dates, locations, etc., at which the formal test procedures were conducted.

To ensure that the SDBM API functions were fully operational, an additional software testing tool was developed specifically to test each SDBM API function. The APITESTER was developed by the Sterling Software SDBM project engineers to test each API function before it was integrated into the SDBM. The APITESTER allowed for all tests to be performed in a known environment with the use of predesignated steps and inputs to produce results that could be observed and used to evaluate the overall operation of each API function.

2.5 Prototype Development and Demonstration

Sterling Software prepared and presented a final technical briefing and demonstration, at the Sterling Rome, NY office, which covered all of the accomplishments under the GCCS SDBM contract and addressed a portion of the CMTK-to-JMTK migration issues. A prototype application was developed by the Sterling Software SDBM engineering staff to demonstrate the capabilities of integrating SDBM into CMTK. This prototype application addressed the issues of accessing data through the SDBM and displaying the results in a CMTK application. The DMA products that were demonstrated were Compressed ARC Digital Raster Graphics (CADRG), Vector Smart Map (VMAP) Level 0, and Digital Terrain Elevation Data (DTED). A Thread Tracker application was also developed and submitted to the Government in order to provide a means to identify and document functional threads within an application or toolkit, such as CMTK, and to provide support to developers and integrators.

SECTION 3 MODULE DESCRIPTION

The Joint services have previously developed and maintained their own software products to support MCC&I requirements. Although functionality is shared by the individual mapping applications, each implementation is unique. To provide the Joint services with a set of common capabilities and a common implementation, the GCCS program is working towards the development of a COE. MCG&I is just one of many functional areas within the COE architecture being addressed by the development of a Joint Mapping Toolkit, which includes the Spatial Data Base Module, the topic of discussion in this Final Technical Report.

The JMTK is being developed as a collection of APIs that enable support applications to interface with MCG&I functionality. Version 3.0 of the JMTK is comprised of three distinct modules: the Visual Module, which provides map presentation functionality; the Analysis Module which performs geospatial computations; and the Spatial Data Base Module, which provides the geospatial data management services.

The Spatial Data Base Module operates in two modes, interactive and server. The interactive mode supports all the user directed activities required by the Spatial Data Base Module. This includes the capabilities to import, manage, and export the data. The server mode encompasses all the capabilities to supply information to a JMTK application. Examples are the queries for metadata, queries to locate specific data, reporting of data dictionary entries, and the reformatting of data. Figure 3-1 correlates the capability requirements of SDBM with these modes. Of the five capability areas, the requirements levied on JMTK 3.0 for the development of the SDBM encompassed three of the capability areas: Spatial Data Import, Spatial Data Management, and Spatial Data Services.

| SDBM CAPABILITY | MODE | |
|---|--------|-------------|
| | Server | Interactive |
| Spatial Data Import <i>Populate the spatial database.</i> | | X |
| Spatial Data Management <i>Manage the spatial database holdings.</i> | | X |
| Spatial Data Manipulation <i>Transform data holdings into a form other than the original input format.</i> | X | |
| Spatial Database Service <i>Provide information about data holdings and data contained in the spatial database.</i> | X | |
| Spatial Data Export <i>Output database holdings for external use.</i> | | X |

Figure 3-1. SDBM Modes

The following sections of this Final Technical Report describe the Spatial Data Base architecture, the set of Application Programmer Interface functions provided by version 3.0 of JMTK, and the Spatial Data Import Application developed to provide a means of populating a spatial data base.

3.1 Spatial Data Base Architecture

The Spatial Data Base Module architecture is based on a hierarchical directory structure of metadata. Figure 3-2 depicts this Spatial Data Base metadata directory structure. Three levels of metadata summarize the actual standard DMA data. The metadata does not contain any actual data within the structure: it simply describes the data and provides information as to where the data is actually located.

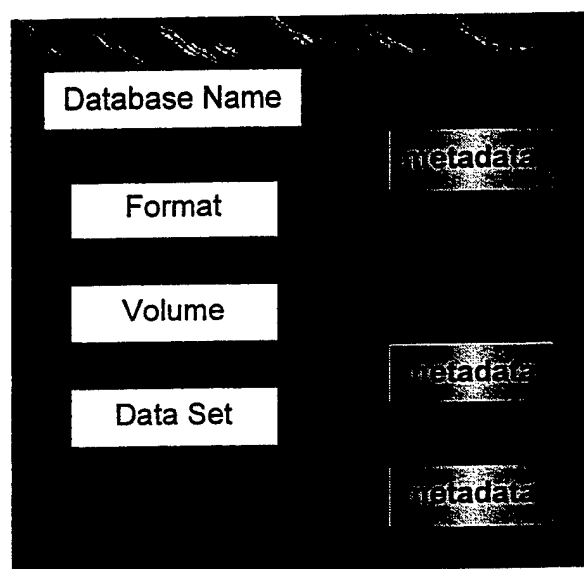


Figure 3-2. Spatial Data Base Architecture

Level 1 metadata provides an overview of the entire data base. Each data base is named at creation. The action of creating a new data base causes a directory structure to be built within the Spatial Data Base environment. The directory is labeled with the data base name and an initial metadata structure is placed within that directory. This metadata structure is continually updated as datasets are added to the data base. A format directory (i.e., VPF, RPF, ELV) is added beneath the data base directory each time a new format is presented for import. No metadata is associated with this directory level.

Level 2 metadata contains information describing volume metadata (i.e., DCW, CADRG, DTED) and all datasets of a particular volume. Each time a new data type, or volume, of data is imported into the data base a directory is built beneath the appropriate Format directory to indicate the new data type. The metadata at the volume level and at the data base level are updated to reflect the addition of the new data.

Level 3 metadata contains information describing a particular dataset which has been imported into a particular data base. As a new dataset is imported into a data base, a directory structure is built beneath the appropriate volume directory and all three levels of metadata are updated accordingly.

For the JMTK 3.0 delivery, a dataset is equivalent to a compact disk (CD) distributed by DMA containing standard DMA formatted data (i.e., VPF, RPF, DTED). Future versions of JMTK will allow a dataset to represent a portion of data taken from a CD. The data itself represented by the metadata can remain on CD, or it can be placed on hard disk during the import process for JMTK 3.0.

The three levels of metadata within the Spatial Data Base architecture will develop and mature, providing additional information about the actual data as future releases of JMTK develop and mature.

3.2 Application Programmer Interface (API)

As depicted in Figure 3-3, the Application Programmer Interface for JMTK provides a means of interaction between common and service specific applications and a JMTK environment. The JMTK environment consists of the three distinct modules, the Visual Module, the Analysis Module, and the Spatial Data Base Module. An initial set of module-related API-level functions have been developed for each of these modules within JMTK 3.0 in order to provide a common and consistent view of the battlefield to all military players. Future versions of JMTK will build upon the initial baseline to provide additional functionality in increments.

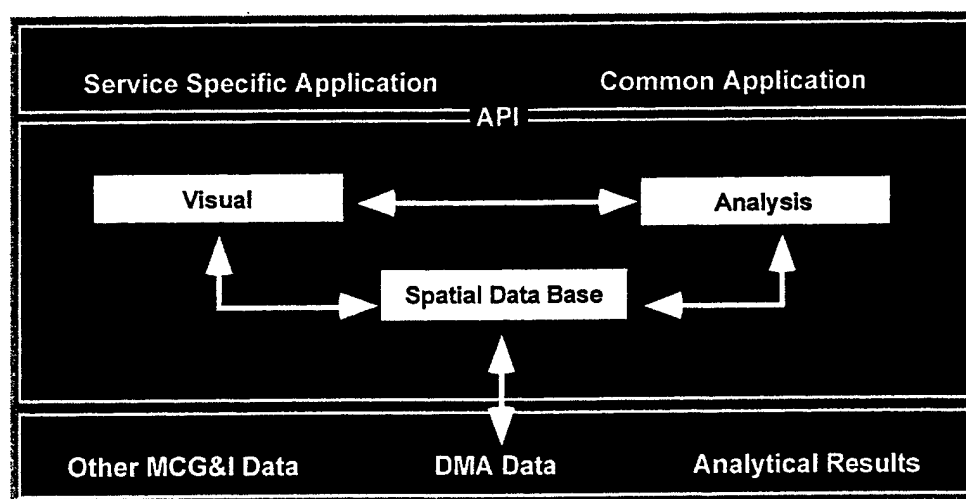


Figure 3-3. GCCS JMTK 3.0 Architecture

Eleven public API functions have been delivered to provide for the access of the Spatial Data Base Module functionality. Thirty-three private API functions have been delivered in support of these eleven public APIs. All the APIs have been developed and documented in accordance with the JMTK Working Group Standards.

The following is a brief description of the eleven public APIs provided for interaction with the Spatial Data Base Module of JMTK 3.0:

JMS_ConfigAOIGet

Allows for retrieval of the current Area-of-Interest (AOI) setting for the current data base connection.

| | |
|----------------------------|---|
| JMS_ConfigAOISet | Defines the geographic area of a spatial data base (i.e., current data base connection) that will be used by subsequent application calls. |
| JMS_DataPathnameGet | Provides path(s) to the actual dataset(s) found in a particular volume located in a particular data base indicated by the current data base connection. |
| JMS_DbConnect | Establishes a unique connection to a currently existing JMTK spatial data base. |
| JMS_DbDisconnect | Terminates a JMTK data base connection. |
| JMS_DbListGet | Retrieves a list of data base names that have been imported into the JMTK spatial data base environment. |
| JMS_ErrorGet | Provides a means of retrieving an error message string related to an error code when an error occurs during execution of an API call to the Spatial Data Base Module. |
| JMS_InventoryGet | Provides a means of retrieving the list of volumes and associated format types for a particular data base indicated by the current data base connection. |
| JMS_MatrixGet | Provides a means of obtaining user-defined matrix data from the Spatial Data Base. |
| JMS_MatrixPut | Provides a means of storing user-defined matrix data in the Spatial Data Base in a way that can be maintained by the SDBM. |
| JMS_MetadataGet | Provides a means of retrieving user requested items from the three levels of metadata within a particular data base indicated by the current data base connection. |

3.3 Import Application

An SDBM Import application was developed during this effort. The application provided the JMTK Spatial Data Base Module developers with a means of populating a Spatial Data Base in the context of a JMTK environment. It also provided a valuable means for testing the API-level functions required for the JMTK 3.0 delivery. Figure 3-4 depicts the initial startup window of the SDBM Import application. SDBM Import users can use the application to create new data bases, import standard DMA data to a data base, populate and maintain the SDBM metadata describing the datasets, verify the format of a standard DMA product, and review data types available in each data base.

It is expected that this application will evolve into an SDBM developer's tool for future versions of JMTK. The way in which it was written provides a baseline tool which can be expanded accordingly to assist in the development of additional API-level functions, provide a resource for testing functionality, provide a resource for regression testing, and provide a method for quickly populating a Spatial Data Base for future versions of JMTK.

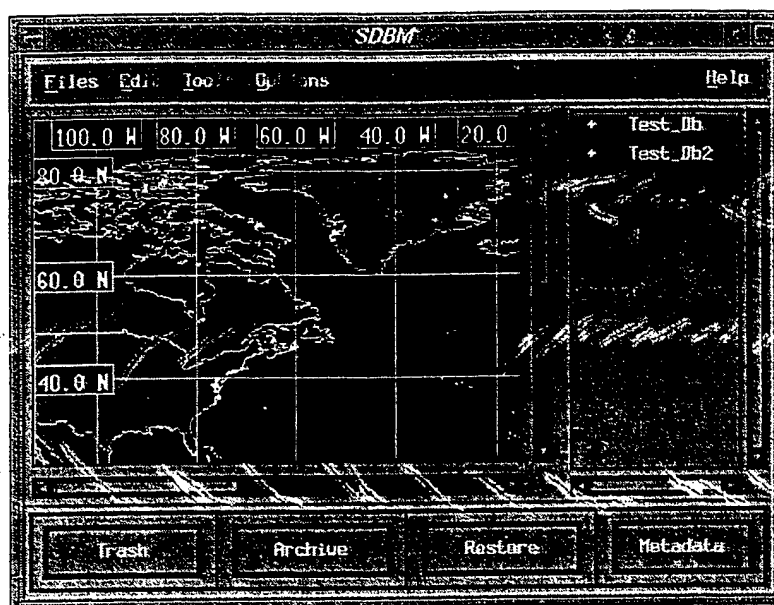


Figure 3-4. SDBM Application Window

SECTION 4 PROTOTYPE INTEGRATION

4.1 Thread Tracking Capability

The Thread Tracking Utility developed under this effort was used to assist in the prototype integration of SDBM into the CMTK. The MACS/Sdt application was exercised with the Thread Tracker in use. Through the use of the Thread Tracker, UNIX utilities, and code review, it was determined that 160 CMTK API functions are currently used by the MACS/Sdt application. These functions were categorized into four functional areas: Visual functions, Spatial Data Base functions, Analysis functions, and Utility functions. The 160 identified CMTK functions represent the mapping functionality required by most U.S. Air Force applications using MACS/CMTK. It is these functions that are targeted for inclusion in JMTK in order to accommodate CMTK users migrating to JMTK. The results of this phase of prototype integration were documented in a Software Engineering Note.

4.2 Migration Approach

The CMTK-to-JMTK migration approach consists of three phases. Phase One was implemented for the Prototype Demonstration in order to demonstrate the proof-of-concept. Phase One entailed the replacement of the CMTK Preprocessor with the Spatial Data Base Manager Import application. The import application provided a means of importing the standard DMA data into a data base environment for use by the CMTK. An interface layer was then built between the CMTK data access calls and the SDBM API. This provided access to the standard DMA data, rather than the preprocessed Common Mapping Standard (CMS) data. The results of Phase One expanded CMTK's data sources to include standard formatted DMA data as well as CMS data, alleviating the use of the preprocessor (100,000 lines of source code) and replacing it with the GCCS/JMTK Import application (20,000 lines of source code). A significant result of the Phase One integration is that existing CMTK applications remain identical to the end user.

Phases Two and Three are future steps of the CMTK-to-JMTK migration plan and were not incorporated into the prototype demonstrating the proof-of-concept. Phase Two consists of building an interface layer between the existing CMTK APIs and the JMTK APIs. The interface layer would be organized into "bindings" which would replace the existing CMTK libraries. This will take the proof-of-concept one step further to a completely functional CMTK application. It would also identify any capabilities that are missing from JMTK. There would be no redevelopment costs for existing CMTK applications to migrate to using the JMTK.

The third and final phase of the CMTK-to-JMTK migration plan consists of calling JMTK directly as new functionality is added to a program. The interface layer would be gradually eliminated as warranted. The result of this three phase migration plan is that existing applications transition to JMTK in a logical manner with minimal impact to the program effort using the CMTK application.

4.3 Prototype Demonstration

The approach Sterling took in developing a demonstration that would show the feasibility of Phase One of the CMTK-to-JMTK Migration Plan entailed several key points. First, an area of

interest was selected where both CMS and standard DMA data were available. Relief shading was selected as the functionality to demonstrate the use of DTED. Vector display/overlay was selected to be used to demonstrate the use of VPF data, and CADRG data was selected to be used for the display of raster data. New SDBM API functions were developed to provide access to the standard VPF and DTED data types. The access of CADRG was previously incorporated into CMTK, therefore that functionality was used to display the CADRG data. Finally, the SDBM API functions were integrated with CMTK v3.2 Beta. The application used to call the toolkit functions, G-Odesy, was not modified in any way in order to accomplish this demonstration.

The data used for the prototype demonstration consisted of 100 meter resolution preprocessed DTED, Digital Chart of the World (DCW) (preprocessed vector data), and CADRG to represent the CMS data. Also used was standard DMA data in the forms of CADRG (RPF), 100 meter DTED, and VMAP Level 0 (VPF). Duplicate hardware configurations were used to demonstrate the prototype and the original CMTK simultaneously. On one platform the original CMTK was exercised via the G-Odesy application. G-Odesy was also used on the other platform to exercise the modified version of CMTK which integrated SDBM to access the standard format DMA data.

To achieve the demonstration, several modifications to the CMTK software were made and additional API functions were developed to access standard DMA data sources stored by the SDBM. The additional API functions included JMS_VPFListGet, JMS_VPFDataRetrieve, JMS_ELVListGet, and JMS_ELVRetrieve. At this point, no additional indexing of the standard DMA data was performed. To demonstrate the proof-of-concept, only five CMTK source code files and two include files were modified in order to provide access to standard DMA data via the Spatial Data Base Module.

The results of the prototype demonstration showed that integration of GCCS/JMTK SDB into the CMTK is feasible. The end user application did not require modification in any way in order to use the SDBM Importer to acquire its data. Standard DMA data was utilized successfully, therefore preprocessed data was not necessary. The display performance of standard DMA DTED data via SDBM was 50% faster than preprocessed CMS data at the 100 meter resolution; the display performance of standard DMA DTED data via SDBM was approximately 40% slower than preprocessed CMS data at the 800 meter resolution due to the fact that the DMA data had to be reformatted from 100 meter resolution on the fly and the CMS data was accessed as 800 meter immediately. The display performance of VPF data was slightly slower than that of comparable CMS data, however the display performance would be improved by incorporating additional data indexing into the SDBM.

Two benefits were immediately realized through the prototype demonstration. By using the standard DMA DTED data at multiple resolutions, there is a reduction of storage requirements. The CMS data would need to be preprocessed and stored at every level of resolution required for display, however standard DMA data could be used at the finest resolution possible and then culled in order to provide a less accurate resolution when that is sufficient. The fact that data does not require preprocessing provides a second benefit; it reduces the costs associated with the building and maintenance of cartographic data bases – a preprocessor is not required to be used, maintained, and exercised in order to build a cartographic data base for SDBM.

SECTION 5 SUMMARY

5.1 Results

The GCCS SDBM effort commenced with an in depth analysis of the overall purpose of the effort. By taking the results from this analysis, a detailed study and correlation of data was conducted to identify the spatial data base management and data access functions that might be needed to satisfy the requirements identified by the JMTK Working Group and the GCCS SDBM SOW. The results of this activity produced the following documents: Software Requirements For The JMTK Spatial Data Base Module and the Spatial Data Base (SDB) Module Version 3.0 API Document. The defined functionality included the creation and manipulation of data bases; the creation, manipulation, and retrieval of product datasets associated with the data bases; and the creation and manipulation of metadata associated with the product datasets. The API functions identified in this phase of the effort guided the remainder of the GCCS SDBM effort.

The second phase of the GCCS SDBM effort entailed the design, implementation, integration, and test of targeted API functions. This part of the effort was aided by the design and development of the SDB Manager and the APITESTER applications. The SDB Manager application performed all of the data base management functions that were identified for inclusion into the GCCS SDBM. The SDB Manager allowed the user to create new data bases, add products to new and/or existing data bases, validated products before importing into existing data bases, and query information about existing data bases. The APITESTER application was a driver used to test the data access functions identified for the GCCS SDBM. Along with being a test driver it also proved to be a working example to developers and integrators in the area of the data access functions.

The third phase of this effort was the final briefing and demonstration phase. This phase of the program consisted of a final briefing to identify and conclude the activities performed under the GCCS SDBM effort. This briefing was presented to DMA and other GCCS development team members. In addition to the final briefing, a proof-of-concept demonstration was assembled to technically support the activities under this effort. In the proof-of-concepts demonstration, the data access functions exercised and tested in the APITESTER application were integrated into an existing application known as G-Odesy, which was developed under an earlier U.S. Air Force contract (Common Mapping Interface Control [CMIC]). The reasons for integrating the API functions into an existing CMTK application was two fold. The first reason for the integration was to demonstrate that the API function could be called from an application to access the products imported into the SDBM and perform queries on information about these products. The second reason for the integration demonstration was to re-enforce the migration concepts set forth by Sterling Software, for transitioning the CMTK-to-JMTK.

All phases were successfully completed, demonstrated, and accepted by the GCCS JMTK Working Group for inclusion into the GCCS COE JMTK.

5.2 Conclusions

Several conclusions can be formulated from the results obtained from the overall GCCS SDBM effort.

The success to date of the SDBM can be attributed to several factors. The first and most significant factor is the evolving of SDBM using a modular methodology. The benefits can clearly be seen for the importance of modularity in a diverse development environment. Under the SDBM effort, the development team consisted of three contractors that conducted their own development at their own sites. In an environment such as this, one might expect many development and integration problems. Well defined, modular software development practices proved to be one of the major success factors of the SDBM effort. Subsequent integration of Sterling Software's SDBM API functions into other application proved to be insignificant and not time consuming. Secondly, the internet connections that were established earlier on in this contract with the development and integration sites played a significant role in the overall software development on this effort. Implementation, integration, testing, and trouble shooting were all done via an internet connection set up between Sterling's development facilities and the GCCS JMTK integration sites. This was most useful in the areas of providing updates to existing software and trouble shooting implementation issues. Updates were performed instantaneously with only developers interaction, questions concerning delivered software were tested and addressed, and configuration management was maintained. By utilizing these concepts it provided a substantial cost savings to both the customer and Sterling Software.

Under this SDBM effort, the prototype implementation of SDBM with CMTK proves that the migration plan is a feasible approach. The benefits that could be achieved under this approach are:

- a. An interface layer between the CMTK data access calls and SDBM, when implemented, would allow for the expansion of the CMTK data sources.
- b. Substitution of the CMTK preprocessor with the SDB Manager import application would replace ~100,000 lines of code with ~20,000 lines of GCCS JMTK code.
- c. As CMTK functionality migrates closer to JMTK, a further reduction in the total number of maintainable lines of code would exist.
- d. The migration plan would allow current CMTK applications to remain identical to the end user.

5.3 Recommendations

Enhancements are necessary to continue to evolve any system. Several recommendations have been made for enhancing the GCCS SDBM data access functionality and the overall design and development of the system. The six following specific recommendations have been noted:

1. The implementation of public API functions to create, manipulate, and delete data bases and product datasets.
2. Secondary VPF tables for processing data would allow for quicker access times.
3. Automating the import process of the product data to provide a more user friendly process.
4. Add the capability to track the import process as it completes its tasks. A "Gas Gauge" could potentially be added to the SDBM to monitor the import process and report back to the user with "percentage complete" information.
5. Dissemination of design and development information via the use of collaborative engineering tools.
6. A firm confirmation to adopt the CMTK-to-JMTK migration plan.

The process of transitioning a system to a working environment is a painstaking undertaking. These recommendations surely will provide for a easier transition from the laboratory to a real-life environment. However, this does not provide complete closure for all areas that might need to be enhanced. This only identifies a very small portion. The continued success of the GCCS SDBM effort is the recognition of potential improvements and to take a step forward to embrace the recommendations.

5.4 References

The following reference documents have been used in the generation of this document.

5.4.1 Government Documents

Content Standard for Digital Geospatial Metadata, Federal Geographic Data Committee, 8 June 1994.

5.4.2 Non-Government Documents

Software Requirements for the Joint Mapping Toolkit/Spatial Data Base Module, Sterling Software/ITD, 8 November 1995.

Software Test Plan for the Joint Mapping Toolkit/Spatial Data Base Module, Sterling Software/ITD, 24 January 1996.

Software Test Description for the Joint Mapping Toolkit/Spatial Data Base Module, Sterling Software/ITD, 7 February 1996.

Software User's Manual for the Joint Mapping Toolkit/Spatial Data Base Module, Sterling Software/ITD, 29 April 1996.

CM Plan for the GCCS Spatial Data Base Module, Sterling Software/ITD, 26 October 1995.

Software Programmer's Manual for the Joint Mapping Toolkit/Spatial Data Base Module, Sterling Software/ITD, 29 April 1996.

GCCS JMTK Spatial Data Base (SDB) Module Version 3.0 Public Application Programmer Interface (API), Sterling Software/ITD, 14 December 1995.

Software Engineering Standards for the GCCS Joint Mapping Toolkit, Joint Mapping Toolkit Working Group, 14 November 1995.

The following list of documents identifies software engineering notes generated by the Sterling Software JMTK development engineering group.

Migration of CMTK to JMTK, Sterling Software/ITD, D Kane, M. Seakan, S. Stoltz, 24 April 1996.

Incorporation of VMAP Level 0 into CMTK v3.2 Beta as a Proof-of-Concept, Sterling Software/ITD, S. Stoltz, 17 April 1996.

Analysis of the Access and Retrieval of Vector Formatted Data in the Spatial Data Base Module (SDBM), Sterling Software/ITD, M. McQuinn, 13 April 1996.

Error Handler for the Spatial Data Base Module (SDBM), Sterling Software/ITD, M. McQuinn, 17 October 1995.

APPENDIX A SDBM TEST ANALYSIS

A.1 Identification

This appendix summarizes and evaluates the results of testing the Spatial Data Base Module (SDBM) Computer Software Configuration Item (CSCI) of the Joint Mapping Toolkit (JMTK).

A.2 Test Overview

The demonstration of the functionality of the Joint Mapping Toolkit Spatial Data Base Module CSCI version 3.0 was conducted at Sterling Software/ITD, Beeches Technical Campus, Route 26N, Rome, New York. The execution of the Formal Qualification Tests (FQT) was held on March 21-22, 1996, witnessed by an Air Force representative of Rome Laboratory. The hardware and software configuration used during the FQT is detailed below.

The Formal Qualification Tests consist of:

1. Spatial Data Import
 - Import VPF Product from CD-ROM
 - Import RPF Product
 - Import Other MC&G Formats
 - JMTK Application Data Import
2. Spatial Data Management
3. Spatial Data Services
 - Data Base Inventory Retrieval
 - Metadata Retrieval
 - Data Retrieval
 - Area-of-Interest (AOI) Creation

Demonstration Test Record

Hardware Configuration: Sun SPARC IPC

Software Configuration: SunOS version 5.4 (Solaris 2.4)
TRITEAL Corporation Common Desktop Environment (CDE)
Motif 1.2.2
X11R5
SDBM version 3.0

Location: Sterling Software
Information Technology Division
Rome, New York

Testing Dates: March 21-22, 1996

Attendees: Major Robert Gibson, USAF Rome Laboratory
Mr. Paul Bell, Sterling Software/ITD
Mr. David Kane, Sterling Software/ITD

Formal Test 1, Spatial Data Import:

- Import VPF Product from CD-ROM

The following subparagraphs provide an overview of the test results obtained from exercising the capabilities defined in Formal Test 1, Import VPF Product from CD-ROM.

- Import VPF Product from CD-ROM Summary

The Spatial Data Import tests were designed to demonstrate the SDBM's capability to populate an existing spatial data base. The Import VPF Product from CD-ROM test demonstrated the capability of the SDBM to import Defense Mapping Agency Vector Product Format data from a CD-ROM into an existing SDBM data base. The table depicted in Figure A-1 summarizes the results of this test.

- Import VPF Product from CD-ROM Record

The date, location, test personnel, and witnesses are listed in the Demonstration Test Record found in Section A.2.

| Formal Test 1, Spatial Data Import | Success | Failure/Errors | Remarks |
|------------------------------------|---------|----------------|---------|
| Import VPF Product from CD-ROM | X | None | None |

Figure A-1. Spatial Data Import – Import VPF Product from CD-ROM

Formal Test 2, Spatial Data Import:

- Import RPF Product

The following subparagraphs provide an overview of the test results obtained from exercising the capabilities defined in Formal Test 2, Import RPF Product.

- Import RPF Product Summary

The Spatial Data Import tests were designed to demonstrate the SDBM's capability to populate an existing spatial data base. The Import RPF Product test demonstrated the capability of the SDBM to import Defense Mapping Agency Raster Product Format (RPF) data into an existing SDBM data base. The table depicted in Figure A-2 summarizes the results of this test.

- Import RPF Product Record

The date, location, test personnel, and witnesses are listed in the Demonstration Test Record found in Section A.2.

| Formal Test 2, Spatial Data Import | Success | Failure/Errors | Remarks |
|------------------------------------|---------|----------------|---------|
| Import RPF Product | X | None | None |

Figure A-2. Spatial Data Import – Import RPF Product

Formal Test 3, Spatial Data Import

- Import Other MC&G Formats

The following subparagraphs provide an overview of the test results obtained from exercising the capabilities defined in Formal Test 3, Import Other MC&G Formats.

- Import Other MC&G Formats Summary

The Spatial Data Import tests were designed to demonstrate the SDBM's capability to populate an existing spatial data base. The Import Other MC&G Formats test demonstrated the capability of the SDBM to import Mapping, Cartography & Geodesy data from a source other than a Vector or Raster format into an existing SDBM data base. This test involved importing Digital Terrain Elevation Data into a previously generated Spatial Data Base. The table depicted in Figure A-3 summarizes the results of this test.

- Import Other MC&G Formats Record

The date, location, test personnel, and witnesses are listed in the Demonstration Test Record found in Section A.2.

| Formal Test 3, Spatial Data Import | Success | Failure/Errors | Remarks |
|------------------------------------|---------|----------------|---------|
| Import Other MC&G Formats | X | None | None |

Figure A-3. Spatial Data Import – Import Other MC&G Formats

Formal Test 4, Spatial Data Import

- JMTK Application Data Import

The following subparagraphs provide an overview of the test results obtained from exercising the capabilities defined in Formal Test 4, JMTK Application Data Import.

- JMTK Application Data Import Summary

The Spatial Data Import tests were designed to demonstrate the SDBM's capability to populate an existing spatial data base. The JMTK Application Data Import test demonstrated the capability of the SDBM to import geospatial and graphic data generated by a JMTK application into an existing SDBM data base. The table depicted in Figure A-4 summarizes the results of this test.

- JMTK Application Data Import Record

The date, location, test personnel, and witnesses are listed in the Demonstration Test Record found in Section A.2.

| Formal Test 4, Spatial Data Import | Success | Failure/Errors | Remarks |
|------------------------------------|---------|----------------|---------|
| JMTK Application Data Import | X | None | None |

Figure A-4. Spatial Data Import – JMTK Application Data Import

Formal Test 5, Spatial Data Management

The following subparagraphs provide an overview of the test results obtained from exercising the capabilities defined in Formal Test 5, Spatial Data Management.

- **Spatial Data Management Summary**

The Spatial Data Management test was designed to demonstrate the SDBM's capability to manage standard DMA product formats such as VPF, RPF, and DTED along with other MCG&I data that may not be in a recognizable format. The Spatial Data Management test demonstrated the capability of the SDBM to create and maintain data bases, create and maintain source files within a data base, and report the data base contents. The test also demonstrated that JMTK users have the ability to store and retrieve data base contents, as well as query on the contents of a SDBM data base via the use of API-level function calls. The table depicted in Figure A-5 summarizes the results of this test.

- **Spatial Data Management Record**

The testing of the Spatial Data Management functions began with Formal Test 5, Spatial Data Management and ended with Formal Test 9, Spatial Data Services – Area-of-Interest Creation, which encompassed all Formal Tests. The date, location, test personnel, and witnesses are listed in the Demonstration Test Record found in Section A.2.

| Formal Test 5, Spatial Data Mgmt | Success | Failure/Errors | Remarks |
|----------------------------------|---------|----------------|---------|
| Spatial Data Management | X | None | None |

Figure A-5. Spatial Data Management

Formal Test 6, Spatial Data Services

- **Data Base Inventory Retrieval**

The following subparagraphs provide an overview of the test results obtained from exercising the capabilities defined in Formal Test 6, Spatial Data Services – Data Base Inventory Retrieval.

- **Data Base Inventory Retrieval Summary**

The Spatial Data Management test was designed to demonstrate the SDBM's capability to obtain an inventory of data base holdings. The Data Base Inventory Retrieval test demonstrated the capability of the SDBM to retrieve a list of data base names, geographic reference, data base type, scale or any combination. Also verified was the capability of the SDBM to retrieve a list of volumes within the data base as well as the list of datasets for each volume. The table depicted in Figure A-6 summarizes the results of this test.

- **Data Base Inventory Retrieval Record**

The date, location, test personnel, and witnesses are listed in the Demonstration Test Record found in Section A.2.

| Formal Test 6, Spatial Data Services | Success | Failure/Errors | Remarks |
|--------------------------------------|---------|----------------|---------|
| Data Base Inventory Retrieval | X | None | None |

Figure A-6. Spatial Data Services – Data Base Inventory Retrieval

Formal Test 7, Spatial Data Services

- Metadata Retrieval

The following subparagraphs provide an overview of the test results obtained from exercising the capabilities defined in Formal Test 7, Spatial Data Services – Metadata Retrieval.

- Metadata Retrieval Summary

The Spatial Data Management test was designed to demonstrate the SDBM's capability to obtain an inventory of data base holdings. The Metadata Retrieval test demonstrated the capability of the SDBM to provide sufficient metadata for each dataset and/or format as well as the overall dataset so as to properly describe the data base, manage its holdings and support data access. The Metadata Retrieval test will verify that the SDBM can retrieve metadata describing an individual data base including the data base name, geographic bounds, total size in bytes, number of volumes, on line status and SDBM version identifier. Also verified was the ability of the SDBM to retrieve metadata for a volume within the data base. The table depicted in Figure A-7 summarizes the results of this test.

- Metadata Retrieval Record

The date, location, test personnel, and witnesses are listed in the Demonstration Test Record found in Section A.2.

| Formal Test 7, Spatial Data Services | Success | Failure/Errors | Remarks |
|--------------------------------------|---------|----------------|---------|
| Metadata Retrieval | X | None | None |

Figure A-7. Spatial Data Services – Metadata Retrieval

Formal Test 8, Spatial Data Services

- Data Retrieval

The following subparagraphs provide an overview of the test results obtained from exercising the capabilities defined in Formal Test 8, Spatial Data Services – Data Retrieval.

- Data Retrieval Summary

The Spatial Data Management test was designed to demonstrate the SDBM's capability to obtain an inventory of data base holdings. The Data Retrieval test demonstrated the capability of the SDBM to retrieve any data product that is stored in the spatial data base. The table depicted in Figure A-8 summarizes the results of this test.

- Data Retrieval Record

The date, location, test personnel, and witnesses are listed in the Demonstration Test Record found in Section A.2.

| Formal Test 8, Spatial Data Services | Success | Failure/Errors | Remarks |
|--------------------------------------|---------|----------------|---------|
| Data Retrieval | X | None | None |

Figure A-8. Spatial Data Services – Data Retrieval

Formal Test 9, Spatial Data Services

- Area-of-Interest (AOI) Creation

The following subparagraphs provide an overview of the test results obtained from exercising the capabilities defined in Formal Test 9, Spatial Data Services – Area-of-Interest Creation.

- Area-of-Interest Creation

The Spatial Data Management test was designed to demonstrate the SDBM's capability to support AOI creation which defines a geographic region that an application intends to interact with. The Area-of-Interest Creation test demonstrated the capability of the SDBM to support the definition of an area-of-interest which defines a geographic region that an application intends to interact with. The table depicted in Figure A-9 summarizes the results of this test.

- Area-of-Interest Creation Record

The date, location, test personnel, and witnesses are listed in the Demonstration Test Record found in Section A.2.

| Formal Test 9, Spatial Data Services | Success | Failure/Errors | Remarks |
|--------------------------------------|---------|----------------|---------|
| Area-of-Interest Creation | X | None | None |

Figure A-9. Spatial Data Services – Area-of-Interest (AOI) Creation

A.3 Joint Mapping Toolkit/Spatial Data Base Module Test Results

For each of the nine tests performed, the expected results identified in the Software Test Description for the Joint Mapping Toolkit/Spatial Data Base Module matched the events/outcome displayed on the screen during testing. As a result the outcome of the tests performed to verify the compliance of the Joint Mapping Toolkit/Spatial Data Base Module to the requirements identified in the Software Test Plan for the Joint Mapping Toolkit/Spatial Data Base Module should be considered successful.

APPENDIX B ACRONYMS

| | |
|--------|---|
| ADRG | ARC Digitized Raster Graphics |
| ADRI | ARC Digitized Raster Imagery |
| AFMSS | Air Force Mission Support System |
| AOI | Area-of-Interest |
| API | Application Programmer Interface |
| C3I | Command, Control, Communications, and Intelligence |
| C4I | Command, Control, Communications, Computers, and Intelligence |
| CADRG | Compressed ARC Digital Raster Graphics |
| CD | Compact Disk |
| CD-ROM | Compact Disk-Read Only Memory |
| CDE | Common Desktop Environment |
| CIB | Controlled Image Base |
| CM | Configuration Management |
| CMIC | Common Mapping Interface Control |
| CMS | Common Mapping Standard |
| CMTK | Common Mapping Toolkit |
| COE | Common Operating Environment |
| COTS | Commercial-Off-The-Shelf |
| CSCI | Computer Software Configuration Item |
| DCW | Digital Chart of the World |
| DFAD | Digital Feature Analysis Data |
| DIS | Data Interchange Services |
| DISA | Defense Information Systems Agency |
| DMA | Defense Mapping Agency |
| DoD | Department of Defense |
| DTED | Digital Terrain Elevation Data |
| EA | Evolutionary Acquisition |
| ED | Evolutionary Development |
| ELV | Elevation |
| FGDC | Federal Geographic Data Committee |
| FQT | Formal Qualification Test |
| GCCS | Global Command and Control System |
| GIS | Geographical Information System |

| | |
|--------|--|
| GOTS | Government-Off-The-Shelf |
| IRRP | Rome Laboratory's Image Products Branch |
| ITD | Information Technology Division |
| JMTK | Joint Mapping Toolkit |
| JSWG | Joint Services Working Group |
| MACS | Mapping Application Client Server |
| MC&G | Mapping, Charting and Geodesy |
| MCG&I | Mapping, Charting, Geodesy, and Imagery |
| NDC | Normalized Device Coordinates |
| NITF | National Imagery Transmission Format |
| PDC | Physical Device Coordinates |
| R&D | Research and Development |
| RL | Rome Laboratory |
| RPF | Raster Product Format |
| SDB | Spatial Data Base |
| SDBM | Spatial Data Base Module |
| SDT | Spatial Display Tool |
| SOW | Statement of Work |
| SRS | Software Requirements Specification |
| TBMCS | Theater Battle Management Core System |
| TEM | Topographic Evaluation Module |
| U.S. | United States |
| USAF | United States Air Force |
| VMAP | Vector Smart Map |
| VPF | Vector Product Format |
| VSC | View Surface Coordinates |
| WWMCCS | World-Wide Military Command and Control System |

APPENDIX C GLOSSARY

Application Programmer's Interface (API): A paradigm used to provide the interfaces between an application and a software library of functions, a toolkit of functions, or another application. The API can also refer to a collection of functions providing the interface capability to a software library, a toolkit of functions, or another application.

Cartographic Display Process: The method used to draw a cartographic map feature (e.g., VPF data features) in the CMTK cartographic window.

Common Mapping Toolkit (CMTK): A software library of functions which provide the capability to display, manipulate, perform geospatial analysis, and otherwise exploit Common Mapping Standard (CMS) data (preprocessed from DMA standard data) as well as other data sources for the United States Air Force.

Common Mapping Standard (CMS): A standardized, Government-owned and DMA-validated cartographic data base structure used as the CMTK data base. The data it incorporates is imported from existing DMA data products such as ADRG, ADRI, DCW, DFAD, DTED, etc. It provides a common format for the use of these varying DMA data products.

Compressed ARC Digitized Raster Graphic (CADRG): A general purpose product, comprising computer-readable digital map and chart images. It supports various weapons: Command, Control, Communications, and Intelligence (C3I) theater battle management; mission planning; and digital moving map systems. CADRG data is derived directly from ADRG and other digital sources through down sampling, filtering, compression, and reformatting to the RPF Standard. CADRG files may be physically formatted within a NITF message.

Controlled Image Base (CIB): A dataset of orthonormalized and rectified grayscale images. A CIB supports various weapons, C3I theater battle management, mission planning, and digital moving map systems. CIB data are derived and produced directly from digital images, and are compressed and reformatted to conform to the RPF Standard.

Dataset Metadata: A Level 3 metadata file within an SDBM Spatial Data Base. It describes a particular dataset found within a data base.

Data Base Metadata: The top level (Level 1) of metadata within an SDBM Spatial Data Base. It describes the contents of a particular data base.

Digital Chart of the World (DCW): A DMA product providing 1:1,000,000 scale vector geographic data. DCW was developed as the initial product implementation of a multinational R&D project designed to develop a set of vector product standards oriented toward the Geographical Information System (GIS) environment. DCW data was derived from Operational Navigational Charts over most of the globe and Jet Navigational Charts over Antarctica. The DCW product is the original name for the current VPF standard product, VMAP Level 0.

Digital Terrain Elevation Data (DTED): A DMA product providing a uniform matrix of terrain elevation values for the earth's surface at 100 meter resolution. The information content is approximately equivalent to a 1:250,000 scale resolution.

GCCS Common Operating Environment (COE): Defines a distributed application infrastructure that promotes interoperability in a reliable and scalable environment. Specifically, a set of

integrated services that support mission software application requirements, and a corresponding software development methodology and environment.

Geographic Reference System (GEOREF): A system used for position reporting. It is an area-designation method used for interservice and interallied position reporting for air defense and strategic operations. Positions are expressed in a form suitable for reporting and plotting on any map or chart graduated in latitude and longitude (with Greenwich as prime meridian) regardless of map projection. Referred to as GEOREF.

G-Odesy: An application which exercises a major portion of the CMTK API-level functions. It was developed during the CMIC effort and is used to provide developers with an environment conducive to modifying, testing, and exercising any portion of the CMTK source code quickly and easily.

Global Command and Control System (GCCS): Will become the single Command, Control, Communications, Computers, and Intelligence (C4I) system to support Joint warfighter. The system objectives are to replace the World-Wide Military Command and Control System (WWMCCS), and to implement the C4I for the Warrior concept. The result will be a single view of the military C4I that improves the Joint warfighter's ability to manage and execute operations.

Graphics Transformation: The conversion of points from one coordinate system to another using a transformation matrix. Graphics transformations include translation, scaling, and rotation.

Joint Mapping Toolkit (JMTK): A collection of application programmer interfaces (APIs) that enable support applications to interface with Mapping, Charting, Geopositioning, and Imagery (MCG&I) functionality. This release of JMTK (version 3.0) is comprised of three distinct modules that interact with each other through the defined APIs. The Visual Module provides map presentation functionality. The Analysis Module performs geospatial computations. The Spatial Data Base Module provides the geospatial data management services.

National Imagery Transmission Format (NITF): A collection of related standards and specifications developed to provide a foundation for interoperability in the dissemination of imagery and imagery-related products among different computer systems, as defined in MIL-STD-2500.

Normalized Device Coordinates (NDC): A coordinate system used to address pixels on a computer graphics screen. The range of this coordinate system is similar to physical device coordinates, except that the largest dimension (width or height) is set to 1.0. The NDC position (0.0, 0.0) is in the lower left corner of the screen. If the width and height are equal, then the upper right corner of the screen is NDC position (1.0, 1.0). If NDC coordinates are used, then graphics objects will take up the same proportion of all computer screens, regardless of the actual PDC dimensions of the screen.

Physical Device Coordinates (PDC): A standard coordinate system used to address pixels on a computer graphics screen. The range of this coordinate system is dependent, but in a typical system the PDC of the upper left pixel will be (0, 0) and the PDC of the lower left pixel will be (width-1, height-1), where width is the number of pixels across the screen in the horizontal direction, and height is the number of pixels across the screen in the vertical direction. Some systems may have PDC (0, 0) in a different corner and PDC (width-1, height-1) in the diagonally opposite corner.

Pixel: A picture element. The smallest addressable area of a computer screen or image file.

Raster Product Format (RPF): A standard data structure for geospatial data bases composed of rectangular arrays of pixel values (e.g., digitized maps or images) in compressed or uncompressed form. RPF is intended to enable application software to use the data in the original format on computer-readable interchange media directly without further manipulations or transformations.

Rotation: A graphics transformation in which a coordinate system is rotated about its origin by a fixed angular value.

Scaling: A graphics transformation in which a coordinate system is resized into a larger or smaller coordinate system with possibly a different aspect ratio.

Spatial Data Base Module (SDBM): The module within the Joint Mapping Toolkit representing all activities dealing with data handling. Those areas include spatial data import, spatial data management, spatial data manipulation, spatial data base services, and spatial data export.

Spatial Display Tool (Sdt): An application developed to provide a single comprehensive, digital multisource MCG&I information handling capability.

Thread Tracker: A utility developed during the development of JMTK 3.0. It provides the capability to track the functional hierarchy, or functional threads, within a toolkit of functions during execution time. It can be turned off and on as needed.

Transformation Matrix: A 3x3 matrix to be multiplied by a point (stored as a vector) to produce a corresponding point (vector) in a different coordinate system. A 3x3 matrix will transform a two dimensional point. A transformation matrix can be as simple as an identity matrix, in which case the output is identical to the input, or any combination of translation, scaling, and rotation matrices.

Translation: A graphics transformation in which a coordinate system is moved vertically and/or horizontally.

Vector Product Format (VPF): The DMA's standard format for vector data. A general user-oriented data format for representing large spatially referenced data bases. VPF is designed to be used directly where software can access the data without time consuming conversion processing. VPF is also designed to be compatible with a wide variety of users, applications, and products.

Vector Smart Map (VMAP) Level 0: The low resolution component of DMA's VMAP family of products. Known as VMAP Level 0, it is a comprehensive 1:1,000,000-scale vector basemap of the world. It consists of geographic, attribute, and textual data stored on CD-ROMs. To show product lineage, it is dual named VMAP Level 0 as well as Digital Chart of the World (DCW). The name VMAP Level 0 will be the only name to continue beyond the initial release of the Vector Smart Map Level 0 data.

View Surface Coordinates (VSC): A coordinate system used to address pixels on a computer screen. The range of this coordinate system is the same as that of PDC, but on all systems the VSC of the lower left pixel will be (0, 0), and the VSC of the upper right pixel will be (width-1, height-1). VSC should be used in place of PDC wherever possible to allow for system portability.

Volume Metadata: A Level 2 metadata file within an SDBM Spatial Data Base. It describes the data types (i.e., DCW, CADRG, DTED) found within a data base and the datasets present for a data type.

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